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ARTIFICIAL FEEDING OF INFANTS WITH SPECIAL RELATION
TO THE MORTALITY DURING THE FIRST YEAR OF LIFE.

BY

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The subject for this thesis has been chosen because of the very high infantile death-rate in England and Wales; and because I consider that it is capable of being greatly reduced by careful attention to the feeding of infants.

The County in which I practise has an infantile mortality rather above the average of England and Wales, but in some of the districts in my immediate vicinity the loss of infant life is so very great, that the serious aspect of affairs has been forcibly brought under my notice.

In the district of Cowpen, a few miles from where I reside, out of every 1000 births in 1903, 222 died during the first year of life; and in the district of Earsdon, which comes partly within the limits of my practice, the death-rate was 200 per 1000 births.

The importance of the subject being thus thrust upon me, I will try to indicate some of the causes which lead to this deplorable condition, and the means that can be taken to remedy it.

Roughly the chief points that I would like to bring before you are: -

Firstly. That the infantile mortality of England and Wales is very high, and shows little sign of de-

creasing.

Secondly. That the general condition of the people has improved, as shown by the decreased general death rate.

Thirdly. That town-dwelling has increased.

Fourthly. That breast feeding has decreased.

Fifthly. That artificial feeding is often erroneously carried out.

The first three of these can be statistically proved as affecting the whole country, and the last two, I believe to exist in this district, and to be the chief causes of the preventable loss of infant life.

The infant death-rate is measured by the proportion of deaths among children under one year of age, to the number of registered births, and this rate has been during the last 50 years as follows: - (1)

| | |
|-------------|------|
| 1851 - 60 | 154 |
| 1861 - 70 | 154 |
| 1871 - 80 | 149 |
| 1881 - 90 | 142 |
| 1891 - 1900 | 154 |
| 1901 - 04 | 141 |
| 1905 | 128. |

This table does not seem to indicate any, or a very slight fall in the rate, and the variations are no doubt due to diarrhoea being epidemic in the hot summers of some of the years included in each quinquennium. In 1898 and in 1899 the rate was over 160 from this cause. 1905 was an exceptionally healthy year, but it indicates that things are improving. This almost stationary infantile mortality has been associated with a great decline in the general death-

rate, a decline of about 16%, comparing 1851 - 1860 with 1896 - 1900.

It is specially notable that during this period the death-rate of children between the ages of 5 and 10 has decreased 50%. These children were living in the same hygienic surroundings, and subject in the same degree to the altered conditions of the community such as increase of town-dwelling and improved sanitation, as the infants under one year, and it is suggestive that some factor in the management of the younger children is counteracting whatever good the sanitarians of the country have effected in the last 40 years. The increase of town-dwelling certainly seems to have a more evil effect on the younger than on the older children.

In Urban counties the infantile mortality is greater than in the rural, and comparing the years 1873-77 with 1898-1902, we find that there has been a small decrease in the rural, and a small increase in the urban mortality; as the following table of Dr Tatham's will show: - (2)

Average rate of Infantile Mortality
per 1000 births.

| In years | Urban Counties | | Rural Counties | |
|-----------|----------------|---------|----------------|---------|
| | Males | Females | Males | Females |
| 1873-77 | 176 | 146 | 140 | 113 |
| 1898-1902 | 180 | 149 | 139 | 111 |

The advantages which the rural infant possesses over the urban one are obviously in the first place - Fresh air; but there is the very important one, that, in the event of artificial feeding being adopted, milk can be obtained in the country which has not passed

some hours in trains and shops; and the fact that fresh milk can be more easily and cheaply obtained, makes it less probable that condensed milk will be used.

The Registrar General's returns clearly show that the urban population is increasing, and the rural decreasing. In 1861 the rural population of England and Wales was 36.6% of the total population, in 1891 28%, and in 1901 23%. This increase of the City population has been due to the migration to the towns of those engaged in agriculture, but it is to be specially noted that the mining population, which is largely classed as rural, has increased. Although this latter population be rural in situation, it has many of the disadvantages of a large town.

Newsholme states that the true index of density of population is the number of persons to each occupied room, and if this index be taken then many of the mining villages are very densely populated. Not only are the houses small, but they are mostly old and closely crowded together, and have remarkably small windows. Then miners, besides having often large families, frequently have adult lodgers as the number of houses in proximity to the pit-head is limited. Thus, though situated in the midst of the country, they have the density of population associated with large towns, and there is not the same stringent inspection of sewage and of refuse disposal. This may to some extent account for the high infantile mortality in the mining districts of Northumberland to which I

have already alluded. Of course the mining population is not large enough to affect the whole rural death-rate, and we find in 1905 the infantile mortality in the seventy six great towns of England and Wales to be 140. In the 141 smaller towns 132, while in the rest of the population it was only 113.

During the ten years 1891-1900 the rate for London was 160, while in Rutlandshire it was only 79. Though we find that this is the general rule, an interesting experiment during 1905 shows that there is no reason why the urban mortality cannot be reduced to a level even below that which at present obtains in the rural counties. Longwood is a suburb of Huddersfield, with a population of 5,359. It has no congested population and no slums; portions of the area are urban, whilst other parts are purely agricultural. The greater part of the population, male and female, are factory workers engaged in the manufacture of woollen goods, with a sprinkling of quarrymen, masons, labourers, and small farmers. Comparatively few of the married women go to work. The death-rate averaged for the last ten years 13.44, and the infantile mortality has been 122. It was therefore a district in which the infantile mortality was comparatively low. The experiment was as follows: - The Mayor of Huddersfield issued a card to the mother of each child born, containing a promise to pay £1 to each infant on its attaining the age of twelve months. The card emphasised the fact that "Mother's Milk is the natural food and the best"; but as an alternative

recommended new milk and water, with cream and sugar in suitable proportions. It also gave some sound advice as to the washing of bottles and other matters. A Committee of ladies visited the mothers and saw that the babies were being properly looked after, and periodic letters of advice were sent. The method seems almost absurdly simple and inadequate; but the results so far speak for themselves. The infantile mortality was reduced to 54. This figure is a great deal below the 75 per 1000 given by Newsholme as the ideal, and cannot be expected to continue.

The year 1905 has been an exceptionally favourable one - the infantile mortality for England and Wales for 1900 - 04 averaged 141, and in 1905 it dropped to 128. Even allowing for errors due to the small population involved on the experiment, the short period of examination and the favourable year, the result shows that an enormous reduction can be made in the mortality with very little supervision. It is to be noted that the ordinary milk supply was used.

In contrasting the causes of death among children in 1873-77 with 1898-1903, (2) we find that the cause of death which shows the greatest increase both in urban and rural districts is diarrhoea, while the death-rate from Tuberculosis, meningitis and convulsions has declined. This suggests that the reason the infantile death-rate has not declined is connected with the alimentary canal, and knowing that breast-fed children are much less liable to diarrhoea, we are forced to the conclusion that the artificial feeding

is at fault.

Dr Cameron investigated the means of feeding in 153 infants dying of diarrhoea in Leeds, during the summer of 1893, and his results show the great risks to which a child is subjected when brought up on the bottle.

Deaths from Diarrhoea and the mode of Feeding, (3)

| Age in months | Cases investigated | Percentage of the 153 | Percentage of those dying fed | | | |
|---------------|--------------------|-----------------------|-------------------------------|----------------------|----------------------|-----------|
| | | | on breast only | partial-ly on breast | not on breast at all | by bottle |
| 0.3 | 41 | 27 | 24 | 20 | 56 | 71 |
| 3.6 | 55 | 36 | 16 | 13 | 71 | 76 |
| 6.9 | 34 | 22 | 3 | 9 | 88 | 91 |
| 9.12 | 23 | 15 | 30 | 17 | 52 | 61 |
| | 153 | 100 | 18 | 14 | 68 | 76 |

The following table of Dr Newsholme (4) shows very clearly the influence that diet has on diarrhoea.

Percentage of infants under one year of age fed in different ways.

| | A. in 2671 houses visited house to house | B. among infants dying of epidemic diarrhoea in 1903 |
|---------------------------------|--|--|
| I. Suckled alone | 61.7 | 6.8 |
| Ditto and farinaceous food | 12.2 | 4.6 |
| " " Cows' milk | 2.1 | 2.2 |
| " " Condensed milk | 0.9 | - |
| II. Cows' milk alone | 8.3 | 27.1 |
| Ditto and farinaceous food | 9.5 | 11.5 |
| III. Condensed milk alone | 2.7 | 43.2 |
| Ditto and farinaceous food | 1.8 | - |
| IV. Patent foods only mentioned | 0.8 | - |
| V. Unknown | - | 4.6 |
| | 100 | 100 |

Dr Newsholme states his conclusions thus: - "The deaths of suckled children were about one ninth of what ought to have occurred on the supposition of average distribution of diarrhoea; the deaths of those suckled, and having also farinaceous food, were about one third; the deaths of those having only cows' milk were about three times, and the deaths of those having condensed milk were about seventeen times the number that ought to have occurred on the supposition of average distribution of diarrhoea among infants fed in different ways. If we assume that feeding plays no part in the causation of diarrhoea these differences are difficult to explain; if, as is practically certain, it plays an important part, then suckling is a very potent means of minimising its incidence."

G. Newman (5) found that 79.4% out of 190 cases of fatal diarrhoea in infants in Finsbury were fed on artificial or cows' milk.

In comparing the infantile mortality of different countries, it is noticed that there are wide variations. These are naturally due to many factors such as climate, sanitation, industrial employment of mothers, and poverty; but there can be no doubt that the most important factor is diet.

In European Countries with the smallest mortality, namely Norway 94, and Sweden 99, it is stated by Cautley (6) that the children are invariably reared at the breast. I do not think this statement is absolutely correct, but I am informed by friends who have made observations in these countries, that

breast feeding is adopted in the great majority of cases.

The European countries with high rates are Russia 272; Austria 228; Hungary 224; and Spain 190 (average of years 1901-02) Newsholme (7). Cautley gives the mortality for Spain as over 30% (6). In these countries the children are constantly brought up on farinaceous foods. The mortality of bottle-fed infants in Spain was, according to Dr Criado, y Aguilar of Madrid, in 1902, between 67 and 80%. Bavaria is another country where feeding with farinaceous foods is common, and Minert states that out of 400 deaths from diarrhoea that came under his observation 90% were fed artificially.

These facts show that the most important factor in determining infant mortality in different countries is feeding. That merely poverty and mal-nutrition of mothers are insufficient reasons (such as may occur in Russia) is shown by the fact that during the Siege of Paris and the Lancashire Cotton famine the infant mortality declined (in Paris 40%), while the adult mortality increased. The reason for this obviously was, that the mothers were compelled to suckle their children and the dangers of artificial feeding were thereby avoided.

It is difficult to prove that breast-feeding has decreased in recent years, as I can find no statistics as to the percentage of children brought up on the bottle twenty years ago, but it is easy to demonstrate how large a proportion of children die artificially

fed at the present time. In my own practice I have examined the feeding of 241 children and find 42.96 mothers are successful in feeding their children with their own milk, or with very little artificial aid. Those who start suckling, but are compelled to leave off within six weeks, owing to insufficient milk, or trouble with the mammary gland, number 29.69% and 27.32% are either utterly unable or unwilling to try to suckle the infant.

I have divided these roughly into two classes, namely, the working class and the rather better class, consisting chiefly of commercial travellers, clerks, and engineers, and tabulate the result thus: -

| | Breast feeding entirely | Breast at first | Artificial |
|---------------|----------------------------|--------------------|------------|
| Working Class | 40.27% | 40.92% | 18.79% |
| Better class | 45.65% | 18.47% | 35.86% |
| Total | 42.96% | 29.69% | 27.32% |

This shows that 57% of the children under my care are brought up artificially, in spite of the fact that my strongest influence has been brought to bear upon the mothers to induce them to adopt the natural method. It will be seen from the table that the working classes have better intentions and really make an effort to suckle, but the force of circumstances is too strong.

In the village of Cullercoats, where a large number of babies included under the "working class" are brought up; the mothers are in the habit of hawking fish after the manner of the Newhaven fishwives.

As soon as they are strong enough after their confinement, they go away with their fish, starting very early in the morning and not getting back till late in the afternoon. They endeavour to suckle the infant when at home, but during the time they are away the babies are fed by the bottle. This system usually breaks down in the first two months, as a rule owing to want of milk, as the breasts are not emptied regularly. It may be noted that the infant mortality is much higher in this district than in the Whitby district, where most of the better class reside, in spite of the fact that the adult fishing population of Cullercoats is distinctly stronger and more robust than that of Whitby, and I am confident that maternal affection is more strongly developed among the fisher folk.

According to Holt (8) in New York, among the well-to-do classes, of those who have earnestly and intelligently attempted to nurse, not more than 25 per cent have been able to continue satisfactorily as long as three months.

Dr G. F. McCleary (9) states that Von Bunge investigated 2000 families in Central Europe and found that 50 per cent of the mothers were unable to nurse, and Marfan in Paris, and Nordheim in Munich, put the physically incapable at 10 per cent.

Handfield Jones (10) inquired at the various London Lying-in Hospitals and found the percentage of those who do not suckle their children to be very small; probably not more than 10 per cent. This ap-

pearsto show that the number of breast fed infants in London is considerably larger than that in the North of England, at least among the poorer classes. These various records indicate that there are very considerable differences in the habits of mothers in different parts of the world. No doubt Von Bunge's figures include both the physically unfit and the economically unfit, namely; those mothers who from their occupations find it impossible to nurse.

To show that artificial feeding of infants is very often badly carried out, is not easy by means of statistics. From the number of erroneously fed infants one meets in practice, one is apt to conclude that nearly all children are fed in a faulty manner, but one must remember that the children that are well and carefully fed seldom come under the notice of the doctor. I find in this district that mothers view fresh cows' milk with suspicion. I do not know whether they consider it too simple a thing on which to feed their children, or whether they have absorbed from the daily newspapers all that has been written in condemnation of impure milk, and have applied that condemnation to all cows' milk. Condensed milk is certainly the favourite in this district. I suppose the cheapness with which it is obtained and the ease with which a bottle can be prepared has much to do with its popularity.

I am sure that the clever advertisements of the proprietary foods have much to do with the maintenance of the high infantile mortality. Mothers eager-

ly read the graphic descriptions of how their baby can be made as fat and healthy looking as the child in the photograph, and then try the food on a baby perhaps a few weeks old. The common result is rickets; less commonly we find scurvy. Rickets in varying degrees is observable in the majority of bottle-fed infants. This being due to lack of fat in the food is more frequent when the patent foods or condensed milk is used, than when cows' milk is used. The usual dilution of cows' milk and water, half and half, gives a deficiency of fat, but not so much as when the tinned foods are in use.

Other faults which we find in artificial feeding as usually carried out, are want of cleanliness in the bottle; the use of a bottle with a long tube which is impossible to sterilise, and irregularity in the hours of feeding. These two last usually go together, as the mother fills the bottle and puts the teat in the baby's mouth and leaves it alone till it begins to cry; then she replaces it, and so on all day.

Another common error in feeding is the use of cornflour; bread; potatoes and other starchy foods during the first months.

The subject of pure milk supply comes under this heading, but as the mothers are not to blame in the matter I will consider it later. A striking corollary on the prevalence of artificial feeding and the faulty method of carrying it out, is found in the fact that among the thirty deaths of infants under one

year that have occurred in my practice during the past few years, twenty four of them were fed either partially or entirely on the bottle, and only six were breast fed.

In addition to the subjects we have already considered in relation to infantile mortality, there are other factors which must be borne in mind, namely:

(1) Industrial occupation of mothers; (2) Premature birth and congenital defects; (3) Hereditary tendencies; (4) Accidental and homicidal violence and (5) the effect of illegitimacy.

The industrial occupation of women brings us back to the feeding question; but it is not only the want of maternal milk, but also the want of maternal care that is felt. It is evident that any cause which deprives the child of its mother for many hours daily must have a bad effect on the child, especially when the mother returns to her child at the close of day worn out with hard work. It is, however, to be noted that among the mining population of Northumberland where the mothers are at home all day the infantile mortality is markedly high. It is also found to be very high in the Welsh towns, such as Rhondda and Merthyr Tydfil where women are not employed. Middlesbrough is another town where a high infant mortality is found, the average for 1891 - 1900 being 182. These towns have a higher average rate than many places where women are largely employed, such as Dundee, which had in the ten years 1891 - 1900

143 per 1000.

Dr G. Reid (11) in his annual report on the health of Staffordshire in 1903 classified "Artisan" towns into three groups. In the first group he placed those in which the proportion of married women and widows engaged in work away from home to total females between the ages of 18 to 50 exceeds 12%; in the second group those towns in which the proportion was under 12% and over 6%; in the third group those in which the proportion was under 6%. He worked out the infant mortality rates for the last two decennial periods (1881-90 and 1891-1900) and for 1901-3 for each of the three groups, with the result that the first group had respectively rates of 195, 212 and 191 per 1000; the second group 165, 175 and 154 and the third group 156, 168 and 146. He attributed the excess of the first group over the second, and the second over the third, to the employment of women away from home, and, as a consequence, the proportion of wholly artificially fed, to entirely, or partially breast fed. These figures appear to show that in Staffordshire at any rate the relationship between industrial employment of women and infantile mortality is very evident.

Premature births and congenital defects may be classed among the more inevitable of the causes of death in infancy. The successful rearing of a premature infant is a difficult thing with incubators and carefully carried out gavage, and it becomes an almost impossible task in the houses of the poor.

The death rate from premature birth has very much increased in recent years. In the years 1873-77 (12) the death-rate of male children under one year, per 1000 births, from premature birth was in the urban counties 14, and in the rural 13, while in 1898-02 it had increased to 22 in the urban and 21 in the rural counties. It is difficult to understand the reason for this, but it may be noted that during the same period the death-rate from atrophy had decreased from 30 to 24 in the urban and 33 to 24 in the rural counties, which suggests that the changes may be due to change of fashion in death certification.

In London it is evident that premature births are becoming a more frequent cause of death. This is shown by Dr J.F.J. Sykes, Medical Officer of Health for St Pancras. Comparing 1876 with 1901, he finds the following differences in the age of infantile deaths.

| | Age in months | | | |
|---|---------------|-------|-------|--------|
| | 3 | 3 - 6 | 6 - 9 | 9 - 12 |
| Percentage change in infantile death-rate in 1901 as compared with 1876 | +12% | +3% | -4% | -22% |

These figures show a great increase in the death rate in the first three months of life. Dr Sykes further shows that this increase took place chiefly in the first month, especially in the first week of life.

The only hereditary tendency which has much bearing on the mortality during the first year of life is syphilis. Although a properly fed infant has a better chance of resisting this disease, still

it must be classed as (with regard to the infant) one of the more inevitable causes of infantile mortality.

Tuberculosis is occasionally directly transmitted; as also may be scarlet fever and small pox, but these have no great bearing on the subject in question. In cases where there is no actual transmission of disease, there may be the transmission of a tendency frequently that of tuberculosis; but this does not usually influence the mortality till after the first year of life. The nutrition of the mother during pregnancy has a very important bearing on the health of the infant when born; but I have very frequently noticed that infants which are born sickly very quickly put on strength if the health of the mother is carefully attended to, and the infant put on the breast. On the other hand, these sickly infants need great skill and constant attention, when they are artificially fed, and it is among these that a considerable proportion of the mortality due to atrophy and mal-nutrition occurs.

Accidental violence, though common enough, is not so frequent as to have much influence on the infantile mortality. The commonest form is overlaying, which occurs, specially on Saturday nights, when the infant is in the same bed with the parents. This ought to be easily prevented even in the poorest classes by providing a box or a basket for the child to sleep in.

The effect of illegitimacy is very great on the

chance of the child living for twelve months. This is largely a matter of feeding, as a very large number of these children are not put to the breast, but fed by some woman who has no great interest in their survival, and does not take the amount of trouble which is always necessary to rear a child by hand.

We have now passed in review various matters connected with infantile mortality which show that artificial feeding is very largely adopted in this country and that the results are often disastrous. That breast feeding ought to be more largely employed, I think we are all agreed, but it is evident that there are factors at work which are causing it to be less frequently employed. Therefore it is necessary to formulate some system of artificial feeding to take the place of the natural method, and having arrived at the best, to urge it most strongly upon the mothers in order to prevent the tremendous wastage of infant life which is taking place year by year in our country. The problem of keeping our infants alive and healthy becomes more important in view of the rapid decrease in the birth rate. It is also to be remembered that these statistics of infant mortality correspond closely to those of infant morbidity, and that when there are a large number of deaths there are a corresponding number of feeble children.

In considering the question of what substitute for mother's milk is to be adopted, the most natural answer would be to use the milk of some other woman.

This reply, however, does not improve the situation, unless the child of the other woman be dead, as one of the infants must be deprived of human milk, the ordinary woman being unable to suckle two children. The question of wet-nursing, however, hardly comes within the scope of this thesis; and in this country we are not able to get wet nurses, even if we desired them.

In the absence of human milk, then, how are we to feed the child? The first point to be considered is the physiological requirements of the infant; then to enquire into the composition of the human milk, and finding that it meets best the needs of the infant, to devise a substitute founded upon cows' milk. The new-born child possesses in proportion to its bulk a larger area of skin surface than the adult. From this surface naturally a large amount of heat is lost, and for this reason, and to counterbalance the deficient heat production from lack of muscular effort, the infant will require, relatively to the adult, a larger amount of "heat producing foods." The child grows very rapidly; more rapidly during the first year of life than at any subsequent period, therefore a large amount of "tissue builders" are required. A very large portion of its time is spent in sleep; and its muscular exertions are confined to throwing about its limbs, crying and suckling. For this reason, the child does not require a great quantity of "energy producers". Of course we can only roughly divide foods into these three groups.

For instance, in the production of heat, fats are the most important, but carbo-hydrates are also of use; and in tissue building, while proteids are the most useful, fats are largely used especially when such important tissues as the bone marrow and nervous system are being rapidly formed.

Foods may be classified as follows: - Water, proteids, carbo-hydrates, fats, and salts. These various ingredients must be mixed in suitable proportions and given in a form that is easily assimilable. Water is essential to life. Three fourths of the weight of the infant is water. The importance of water to the child is shown by the fact that four fifths of the constituents of human milk is water. Water is lost by sweat, urine, faeces and expired air; and as has been already mentioned, the skin surface of the infant is proportionately greater than in the adult; so a greater amount is lost in sweat.

The child needs about six times as much water as the adult in proportion to its bulk.

Children soon show the effects of want of water, this is easily seen in an attack of diarrhoea and vomiting when the loss of water causes very rapid wasting. It is very difficult to get mothers to appreciate the value of plain water for infants between meals, but once they have been prevailed upon to try the effect of hot water on an infant that is crying from dyspepsia they become enthusiastic on the subject. It is surprising that the traditions of child-rearing which are in many respects true do not

contain a recommendation to try hot water. Water by diluting food renders it more easy of digestion. It also acts as a solvent of sugar and salts, rendering them capable of absorption. It also dilutes the contents of the intestine, and so prevents constipation. Jacobi says water increases the secretion of pepsin and hydrochloric acid.

Proteids are also essential to life, and they are specially of value to the growing child. They constitute the only food that is capable of replacing the continuous nitrogenous waste. They may sustain life for a time without the aid of fats, or carbohydrates, but the strain upon the kidneys and the digestion is too great.

The adult man of 67 kilogrammes' weight requires 100 grammes of proteid daily; while an infant of 6.7 kilogrammes needs about 20 grammes.

The proportionate increase in weight in the young of various animals seems to be in ratio to the amount of proteid contained in the milk of the mothers . An infant's weight (13) is doubled in about 180 days with human milk containing 1.5% of proteid; a foal in 60 days with 2%; a calf in 47 days with 3.5%, a goat in 19 days with 4.3%, a pig in 18 days with 5.9%, a lamb in 10 days with 6.5%, a kitten in $9\frac{1}{2}$ days with 7%, a dog in 8 days with 7.3%, and a rabbit in 7 days with 10.4% of proteid.

The milks of these animals contain, as well as a greater amount of proteid, a larger quantity of ash; lime, and phosphoric acid. (The most digestible pro-

teid for the infant is the albumen contained in human milk, and one of the difficulties of artificial feeding is to give the child sufficient proteid without disordering the digestion.

The caseinogen and last-albumen of cows' milk are the most frequent substitutes used, but the myosin of meat; egg-albumen and gluten are also of use. Vegetable proteids are not so easily digested as animal. A considerable portion of the proteid taken by the infant is passed unchanged in the faeces, and no doubt this accounts for the large differences in the amount of proteid recommended by various authorities on infant feeding.

The most constant symptom of proteid deficiency is anaemia. The circulation also becomes feeble, and the muscles flabby. The child ceases to grow, and dentition is delayed. Children whose diet has insufficient proteid are very apt to succumb to acute disease; while an excess of proteid gives rise to indigestion, colic, and constipation, or diarrhoea.

The uses of fats are intimately associated with those of proteid. They possess the important faculty of saving tissue waste, and by maintaining animal heat allow all the force of the proteids to be spent in tissue formation. Also, to a certain extent, they act as tissue formers.

The infant is laying down a considerable amount of tissue rich in fat, such as the bone marrow; the nervous system; and subcutaneous fat; and it is probable, though not proven; that the fat taken as food

goes towards the formation of those tissues. At any rate, it is certain that if the diet is deficient in fat, the fat already stored in the body is drawn upon to supply the requirements of the child for animal heat.

As has already been stated, the infant loses more heat proportionately than the adult, and as fat is the chief producer of heat, it is thus required in much larger quantity by the child. An infant weighing 6.7 kilogrammes requires about 40 grammes of fat; whereas an adult weighing 67 kilogrammes does not need more than 100 grammes.

Rickets occurs when fat is deficient. The reason for this appears to be that fat in some way aids the absorption from the intestines of earthy phosphates. Young animals (14) were given milk from which the fat was separated, and it was found that the absorption of phosphoric acid was much interfered with. Fats, however, are not entirely absorbed, as they are invariably found in the faeces. They act as a natural aperient, and are the chief cause of the soft condition of normal infantile stools.

The effect of deficiency in fat which is first apparent is constipation. If the child is liberally supplied with carbohydrates it does not become thinner, in fact, many of the fattest infants have been fed upon a diet deficient in fat; usually one of the patent foods.

The most dangerous condition which arises in children who do not get enough fat is rickets. This

only becomes apparent after a considerable time, which makes the condition all the more serious. Excess of fat is not a common fault in infant feeding, and is most usually met with in breast-fed children causing diarrhoea and vomiting.

Carbohydrates are not so important to the infant as either fats or proteids. They are more often in excess than deficient in artificial feeding. Together with the fats they are useful in maintaining the body heat. They also help in the formation of fat in the body, and provide energy for the muscular exertions of the child. They, as well as the fats, act as "proteid spacers", namely by supplying energy they allow the proteids to be used for tissue formation.

When Carbohydrates are given in excess, as in the case of patent foods, the child is usually very fat. And this excess also predisposes to fermentation in the intestines with griping, flatulence, and diarrhoea.

Deficiency in carbohydrates is very rarely met with. Carbohydrates must be given in the form of sugar. Lactose or milk sugar is the only carbohydrate found in human milk, therefore it is the most likely form to be digested by infants. It is, however, found that as a general rule cane sugar does just as well. According to the old experiment of Claude Bernard, lactose can be utilised unchanged for nutrition, while cane sugar requires conversion into dextrose before it can be used. This process

seems to go on quite naturally in the infant.

There is this important difference between the two sugars, that cane sugar readily undergoes alcoholic fermentation, while the fermentation which goes on in milk sugar is that of lactic acid. Whether this be the reason or not, I have frequently observed that children who have been suffering from flatulence and colic when fed with cane sugar, become easy when the sugar is altered to lactose. It is doubtful whether the lactose of commerce is the same as that of human milk.

The capacity of the infant to digest starch, or rather the age at which that capacity begins, is a question that has been much investigated. The advantage of giving starch seems very questionable when it is found that a soluble carbohydrate in the shape of sugar is easily digested. Not until about the third month is saliva secreted in any quantity. As there is very little hydrochloric acid secreted by the infantile stomach, any saliva which is swallowed can there invert the starch. It is certain that some starch is absorbed, as Heubner and Carst^{ens}~~ains~~ analysed the faeces ^{of young infants} after administering a certain quantity of starch, and found that some had been absorbed.

Both the secretions of the salivary glands and the pancreas, have, in the infant of seven days old the power of inverting starch. This power is small at first, and goes on increasing during the first year. Jacobi and Zweifel found that an infusion of parotid of an infant seven days old after death had a dias-

tasic effect.

Jacobi states that the pancreas has a similar action from the fourth week onwards, but the action is slight until the fourth month. (15)

These observations show that it is possible for the infant to digest starch, and we see infants every day consuming large quantities in the shape of barley and oatmeal water, or patent foods without apparent ill-effect; but there seems to be no good reason why the feeble power of the infant should be strained in this respect. The reasons for giving barley water, however, are not wholly on account of the nutriment which the child may absorb from it.

Salts are necessary to the child; and in order to be assimilated they must be in organic combination with proteids. If salts were extracted from milk and then added in watery solution, they would be of little use to the infant (16). Salts are chiefly utilised in building up the osseous system.

The most important are the phosphates of lime and magnesium, iron, and the chloride of sodium.. The amount of lime salts required is smaller than the quantity found in cows' milk, and the presence of an excess of lime salts renders the curdling of milk by rennet more rapid, and produces a firmer clot. It will afterwards be shown that by the addition of Citrate of soda to cows' milk this state of affairs is remedied.

Naturally, human milk meets the requirements of the child more accurately than any substitute, and

we have now to devise the substitute which most nearly agrees with human milk in composition and properties.

The only milk which we need seriously consider is that of the cow. Asses' milk may sometimes be of use, but the amount produced in this country is so small that it cannot be commonly used. Both cows' milk, and human milk usually contain micro-organisms, but these differ greatly in number and character.

Human milk was found to be sterile in 5 women out of 48 by Cohn and Neumann (17), and Kostlin found micro-organisms in 91%.

The microbes usually present are - staphylococcus pyogenes albus and aureus and streptococcus pyogenes. Of these the first greatly preponderates. These microbes, however, are very few in number and only occur in the milk that is first secreted, the rest of the milk being sterile. Cows' milk contains an immense number of microbes, and these are of a character which are capable of doing much more damage than the few staphylococci found in human milk. G. Newman (18), Medical Officer of Health for Finsbury, has found as many as 4,800,000 bacteria per cubic centimetre in fresh milk in a first rate London shop. In Liverpool from 1900 to 1902, 788 "Country" milks were examined and 55% of them contained B. coli and 9% B. Enteritidis sporogenes; of 722 "town" milks 23% contained the former and 4% the latter.

These dangerous bacteria are no doubt the cause

of the greater number of deaths from diarrhoea in bottle than in breast-fed infants. Another microbe that is frequently found in cows' milk is the tubercle bacillus. It is found in a varying number of milks in different towns, from 14% of the milks examined in Berlin in 1898, to nil in Finsbury (18).

In Liverpool the milk has been examined for Tubercle bacillus from 1896 to 1903, with the result that the percentage of milks containing the Bacillus has varied from 0.6 to 17%. The microbe of diphtheria has rarely been found. It was isolated by Bowhill in S. Wales epidemic in 1899, (19) and by Eyre in the same year; (20) also by Klein in 1900; (21) and Dean and Ford in 1902. (22) Apart from these pyogenic organisms, the most common microbe found in cows' milk, are lactic acid forming, butyric acid forming, and peptonising. The lactic acid Bacillus is the most common cause of the souring of milk, and the acidity of milk may be taken as a fair test of the number of micro-organisms present, provided that no preservative has been added, or the milk raised to a temperature that would destroy the lactic acid bacillus without destroying the others.

To reduce this milk swarming with microbes to the almost sterile condition of human milk, heat is frequently employed. It is raised to a temperature of 70° C. and rapidly cooled in the Pasteurisation method, being kept at 70° for twenty to thirty minutes. This destroys all the ordinary pyogenic microbes, such as Bacteria coli, and also those of

Diphtheria, tubercle and typhoid.

The advantages of this method are that the taste and smell of the milk are unaltered and that probably the chemical character of the milk is not much changed. But even this raising of temperature seems to be sufficient to destroy the anti-scorbutic property of the milk. The milk may be sterilised either by simple boiling, or by means of a steam steriliser. This destroys more completely the germs, but has the disadvantage of altering the taste and smell of the milk.

While these processes destroy the microbes in milk, there are three other effects that we have to consider, namely, the effect of heat on the coagulability by rennet; on the digestion by the gastric juices, and on the antiscorbutic properties.

Dr F.S. Curgenvin (23) found by laboratory experiments that boiled milk curdled more slowly, and less firmly with rennet; that the curd of boiled milk was heavier; due to the albumen, and that the curd of boiled milk was more readily digested than that of unboiled. Hence, as it formed more slowly and less firmly, the gastric juices had a better chance to act.

E. Cautley (24) found that the longer milk was heated and the higher the degree of heat, the greater was the amount of rennet required to coagulate a given quantity. The rate of coagulation was slowed and the resulting curd was softer.

Heat also reduced the coagulability of milk with

acetic acid to a small extent. He suggests as a reason why undiluted sterilised milk can be given with impunity is that the milk does not coagulate in the stomach, and so the milk passes more easily and quickly through the pylorus. Gastric digestion is improved by the juice being able to mix more freely with the milk; but is impaired by the fact that the milk stays for a shorter time in the stomach, and gastric digestion is replaced by intestinal.

In connection with this, it may be stated that it is the practice of Budin, in France, to feed infants with undiluted sterilised milk, and that it is done with great success.

Scurvy is usually found in children who have been fed on milk which has been heated or condensed, or on proprietary infant foods.

The following statistic (25) shows this: -

| | | | | | |
|-------------------|-------------------------------|---------------------------|---|---|-------|
| Previous foods | { Breast milk | in 12 cases; alone in 10. | | | |
| | { Raw Cows' milk | " 5 | " | " | " 4. |
| | { Pasteurised Milk | " 20 | " | " | " 16. |
| | { Condensed Milk | " 60 | " | " | " 32. |
| | { Sterilised Milk | " 107 | " | " | " 68. |
| | { Proprietary Infant foods | " 214 cases. | | | |

Dr Holt finds (26) in 60 cases of scurvy a similar condition of things, and he concludes that the heating of milk is the cause of the disease. The greater the temperature to which the milk is raised, the greater the risk of scurvy.

^{ss}
Vailieff found in experimenting on adults that the nitrogenous ingredients of boiled milk are less readily assimilated than unboiled; and also that the fat is less readily assimilated when the milk is

boiled.

These experiments were made by examination of the faeces and urine. Taking these various facts into consideration, I am of opinion that it is advisable to give the milk unboiled as a general rule; but that when epidemic diarrhoea is to be feared the microbes ought to be got rid of by Pasteurisation. The risks from mal-assimilation and from scurvy are less than those of diarrhoea, especially as it is only after prolonged feeding with heated milk that scurvy becomes evident. It is also well to boil the milk when diphtheria is prevalent, or when it is known that the milk takes an excessive time in getting from the dairy to the consumer.

In comparing the percentage composition of human with cows' milk, one has always to bear in mind that like all animal secretions they differ in composition in different individuals and in the same individual at different times.

In order to arrive at a table which may be taken as a standard, I have struck an average of recent analyses. The older methods of analysis seem to have erred in giving too high a percentage of proteid and too low a percentage of sugar.

Standard comparative Table of Human and Cows' Milk

| | <u>Cows' Milk</u> | <u>Human Milk</u> |
|----------|-------------------|-------------------|
| Water | 87.6 | 87.6 |
| Solids | 12.1 | 12.3 |
| Fats | 3.5 | 4 |
| Proteids | 3.5 | 1.6 |
| Sugar | 4.5 | 6.5 |
| Salts | 0.6 | 0.2 |
| | Acid | Alkaline |

It will be noted that cows' milk is much richer in proteids and salts while it is poorer in sugar. The proteids are not only very different in quantity, but also in quality. They consist in both cases of casein and lact-albumen, also a small quantity of lactoglobulin, which may be disregarded. The relative proportions of these two proteids in cows' milk is given very variously by different observers, but the average result is that the casein exists in a proportion of six to one of the lact albumen. In woman's milk, on the other hand, they appear to exist in equal proportions, some observers giving the albumen as greater and others the casein. The albumen is the more easily digested of the two, and is in much greater proportion in the human milk. The casein of the cows' milk differs from that of the woman's in being easily coagulated by rennet forming a tough curd, and this curd on digestion, leaves behind it an indigestible residue of para-nuclein. The action of rennet on human casein is uncertain, but almost invariably no coagulation takes place. Cows' casein is readily coagulated with acids, being thrown down in large flocculi which do not readily dissolve in excess, while human casein is only slightly coagulated with acids and is thrown down in fine flocculi, which are readily dissolved in excess. The fat in human milk is in smaller globules, has a lower melting point, due to containing more oleic acid, (27) and has much less of the soluble or volatile fatty acids. (28)

In the salts of the two milks there is an im-

portant difference in the way in which the phosphorus is combined. In the human milk the phosphorus is almost entirely organically combined, mostly in the form of lecithin (27) 33% and phosphocarnic acid 41%, while in cows' milk less than half is in organic combination, lecithin 5% and phosphocarnic acid 6% (29).

As phosphorus is of great importance to the growing infant and organic combinations are much more easily assimilated, this fact is of importance.

The inorganic salts are present in greater amount in cows' milk. This is chiefly due to the calcium salts as there are less potassium salts and iron oxide in the milk of the cow. The importance of this excess of calcium salts I will deal with when considering the value of citrate of soda as a means of decalcifying cows' milk.

Cows' milk that is to be used for the feeding of infants ought to be as fresh and clean as possible. Milk runs risks of contamination in the byres and farm dairies, in transit, and in delivery to the consumer. It also may be contaminated in the house of the consumer. The more certain we are of the care that is employed in milking and transmission, the less the necessity of boiling milk.

The cows ought to be well fed and have an abundant supply of good drinking water. They ought not to have much exercise. The byres ought to be well ventilated and capable of being easily cleaned and before milking ought to be thoroughly cleaned. The

cow ought to be groomed like a horse, but this is seldom done in this country. The milker's hands ought to be well washed and he ought to wear clean clothes. All the dairy utensils should be sterilised by boiling. The milk ought to be strained and rapidly cooled down to 40°, and then the ideal method would be to transfer it at once to sterile bottles which should be sealed and not opened till in the customer's house. The system of delivering milk in bottles is becoming quite common, but I find that the bottles in which I receive my milk are filled at the milk-shop, sometimes, indeed, out of an open pan which stands upon the counter. The bottle system is carried out correctly in Paris, and in some American cities, (30) but it is certainly not so in this district. The cattle ought to be subjected to the Tuberculin test, and those showing signs of tuberculosis should be destroyed. This would get rid of the frequent presence of tubercle bacilli in milk, which must be a danger to the infant, whether the tubercle of cattle is identical with that of human beings or no. The Bacillus is, as a rule, only found in milk when the udder is affected (31) and according to Macfadyen (32) 2% of cattle in the milking herds of this country suffer from this disease. According to Geddes (33) in 1901-1902, 17.92% of dairy cows in Great Britain and Ireland were suffering from tuberculosis of some organ, and if the cow has tuberculosis, her udder may become infected at any moment.

Milk ought to be conveyed from the cow to the

consumer in as short a time as possible. It is surely unnecessary that milk should be sent from Kirkcudbright to the London market, a distance of 359 miles. Markets should be arranged by the dairy farmers so that the milk is sent to the consumers which can be most rapidly supplied. Some of the milk used in London takes as long as 12 hours in Railway travelling alone. This must be quite unsuitable food for infants by the time it reaches the consumer. It is in milk of this character that there is the temptation to use preservatives because of the tendency that long-travelled milk has to early souring. Now the souring is of great advantage to the public as it shows that the milk is bad. By the addition of preservatives this souring is prevented by killing the comparatively harmless lactic acid bacilli, but the milk is still bad and swarming with bacteria which borax, boracic acid or other preservatives used are unable to destroy. Thus, apart from the evil effects these preservatives may have upon the infant, such milk ought to be avoided if it can be detected.

The milk must not be adulterated with water, as by so doing the proportion of fat is lowered, and the fat is the ingredient in infant feeding which is most commonly deficient.

Having secured a wholesome milk from clean byres and healthy cows, carefully milked, and rapidly conveyed to the consumer; the next thing to do is to so modify the cows' milk that it becomes easily digested by the child, and at the same time gives the proportion

of ingredients that is requisite for the physiological requirements of infancy.

It is found that some infants who cannot digest raw milk do well when the milk is boiled. This is due to the difference in the action of rennet on the milk.

As has been already shown the result of the action of rennet and the gastric juice of infants upon cows' milk is the formation of a firm, tough curd. It is necessary to use some means whereby this curd may be made to resemble that of human milk. But this curd cannot be made identical with that human milk because of the differences in the proteids in the two milks. There are several different methods that may be adopted for this purpose: (1) simple dilution; (2) dilution with barley or oatmeal water; (3) dilution with lime water; (4) the addition of bi-carbonate of soda; (5) the addition of citrate of soda; (6) separation of the caseinogen from the lact-albumen; and (7) pre-digestion.

As the cause of the toughness of the curd is the richness of cows' milk in casein, and the soluble salts of lime; then it is obvious that dilution will make the curd less dense and as, in order to reduce the proteid to an amount suitable to the requirements of the infant, dilution is also necessary, so we always have to dilute cows' milk. In opposition to this it may be said, as already stated, that Budin, in France, feeds infants successfully on undiluted boiled milk, and F.G. Haworth (34) uses undiluted

raw milk with the addition of 5% of lime water. In this mode of feeding it is apparent that the excess of proteid must throw an extra strain upon the infant's kidneys without any increased advantage to the child's nutrition.

It is necessary to dilute cows' milk four or five times in order to obtain, with acetic acid, a curd like that produced by the addition of the same acid to human milk; (35) and this dilution gives too little proteid for the nourishment of the infant, it reduces the proteid to .7%, against 1.5%, which is the proportion found in human milk. It is not advisable to reduce the proteid much below 1.5% except in some infants of feeble digestion and then only for a short period.

The majority of the youngest infants are able to digest the curd produced by cows' milk and water, equal parts.

Dilution by barley water has no greater power of preventing clotting than ordinary water, but, by its viscosity, it seems to prevent the clot from forming into a tough mass. It has the disadvantage that parents, with a view to "feeding" the infant, make it as thick as possible and so give the child a good deal of unnecessary starch.

Dilution with lime water is more efficacious than either simple water or barley water. Lime water seems to have a specific action in the prevention of the clotting of milk which is not due simply to its alkalinity. It probably precipitates the soluble lime

salts in the same way as it is of use in the softening of water by the "Clark" process. Bi-carbonate of soda is often added to milk, but its use is not very apparent. It reduces the acidity of the milk, but is soon rendered inactive by the acid of the gastric juice.

In my experience the most useful way of making the curd of cows' milk digestible is by the addition of citrate of soda. This method was brought before the profession by Dr F. J. Poynton (36) and has been used in the Hospital for Sick Children, Great Ormond Street. In the following year (37) Dr Poynton gave a satisfactory account of its employment. The principle of the method was indicated by Professor Wright in 1893 (38) and again alluded to by the same writer in 1902. (39) In his note Wright gave the following as the foundation of the theory. Arthus and Pagés had ascertained that cows' milk when treated with oxalates and fluorides did not clot with rennet, because the lime salts had been precipitated by their addition. If, on the contrary, instead of adding these salts, lime salts were added to the milk the clot that formed with rennet was denser than usual. Dr Wright said that the firm rennet clot takes place in digestion when the stomach is empty and the loose acid clot when the stomach is full. He believed that much of the milk dyspepsia of infants was the result of the indigestibility of the rennet curd of the cows' milk, for it is the rennet curd that is formed when the stomach is empty. If then, as Arthus

and Pagés observed, some of the lime salts in the cows' milk are precipitated the clotting by rennet will be delayed, and be less firm in its consistence, and thus become more digestible. Further, cows' milk can afford this precipitation of some of its lime salts because they are present in it in great excess as compared with human milk. The oxalates and fluorides used by Arthus and Pagés are, however, poisonous salts; for this reason Dr Wright suggested citrate of soda as the re-agent for the practical application of the principle to the problem of infant feeding.

Dr Poynton tried the following experiment (36) He took three tubes each containing an ounce of milk. Tube I contained unboiled milk, Tube II boiled milk, and Tube III boiled milk with three grains of citrate of soda. To each of these was added five drops of rennet and five drops of a 0.5 per cent solution of hydrochloric acid, The tubes were placed in an incubator, and in Tubes I and II massive clots were formed, while in Tube III there was a very fine clot, the fluid looking more translucent than the others. If, instead of using three grains, two were used, the clot was less fine, and with one grain still less so. He found that the usual quantity required in infant feeding was one grain to the ounce.

Another method of rendering the proteid of cows' milk more digestible is to remove totally, or partially, the casein. This can be done by means of whey which contains lact-albumen 0.86%, fat 0.32%,

sugar 4.79%. salts 0.65% and water 93.38. (40) If the milk be diluted with whey, the proportion of lact-albumen to casein will be increased, and the dilution can be carried much further than with water, without reducing the proteids to too low a figure.

The last method which may be adopted is that of predigesting the proteid. The most convenient method of doing this is by means of Fairchild's Peptogenic milk powder, which consists of pancreatin, bi-carbonate of soda, and milk sugar, and is added to a mixture of milk, cream, and water; The mixture is kept at a temperature of about 120° F. for six minutes. The result is that a fine, easily assimilated curd is produced, but the disadvantage of this method is, that it does not stimulate the functions of the infant's stomach, and if kept up for any length of time the stomach becomes incapable of digesting milk. It is, however, very useful over short periods; and the amount of predigestion can be lessened by shortening the time in which the ferment is allowed to act. Another objection to the use of predigestion of milk by any method is, that it needs to be carefully carried out; and this care can seldom be obtained in the houses of the poor.

Cows' milk must be diluted to render the proteids digestible, and this dilution reduces the fat and sugar in the mixture to a point considerably below that of human milk.

Results of dilution.

| | Human | Cows | Cows milk 2 parts water 1 pt. | Cows milk 1 part. water 1 pt. | Cows milk 1 part. water 2 pts. |
|---------|-------|------|-------------------------------------|-------------------------------------|--------------------------------------|
| Proteid | 1.6 | 3.5 | 2.8 | 2.00 | 1.33 |
| Fat | 4. | 3.5 | 2.8 | 2.00 | 1.33 |
| Sugar | 6.5 | 4.5 | 3.00 | 2.25 | 1.5 |
| Salts. | 0.2 | 0.6 | 0.40 | 0.30 | 0.20 |

This table shows that even with two parts of cows' milk to one of water there is too little fat. There are various methods of making up this deficiency. The simplest is by the addition of ordinary cream which contains from 16 to 20% of fat. Separated cream contains from 35 to 40% of fat, and has the advantage that it can be delivered to the consumer 24 to 36 hours sooner. The process of separation seems to break up the fat globules, and one often sees that when it is added to milk, and then heated, that the fat rises to the surface of the bottle as visible globules. These are more difficult of digestion than the finely emulsified fat of milk. Either cream, however, will do, but it must be remembered that to arrive at approximately the same proportion of fat in the mixture, one third more of gravity cream must be added. In dealing with cows' milk containing 3.5% of fat, a satisfactory formula is cream (20% fat) 2 teaspoonfuls; milk, 6 teaspoonfuls; water 2 tablespoonfuls; one small teaspoonful of sugar, and either two teaspoonfuls of lime water, or a teaspoonful of a solution of citrate of soda, 8 grains to the ounce.

The percentage composition of this mixture is -

| | |
|---------|------|
| Proteid | 2% |
| Fat | 3.5% |
| Sugar | 7.5% |
| Salts | 0.3% |

The proteids are somewhat in excess, but I have found it a satisfactory mixture, and if not digested with the lime water, I have usually found no pain or vomiting when the citrate of soda is substituted, The amount of proteid may be diminished by giving a larger proportion of cream and adding more water.

In some households cream is too expensive to be used, and in such I am in the habit of roughly using the "top milk" system. It is not possible to use it accurately without a vessel constructed so that either the bottom two thirds, or the top third can be run off separately. My method consists in simply ladling the necessary quantity from the top of milk that has been standing carefully covered in a cold place for four hours. It has been found by experiment at the Walker-Gordon Farm at Plainsboro (41) that after four hours the upper fourth will contain all the cream that will rise, and that the upper layers contain almost the same percentage of fat, whether the milk has stood for four hours, or over night.

The following was the result of these experiments: -

| Percentage of fat in | After 4 hours | After 8 hrs. | Over night |
|----------------------|---------------|--------------|------------|
| Upper 4 oz. | 20.5 | 21.25 | 22.00 |
| Second 4 oz. | 6.0 | 6.5 | 6.5 |
| Third 4 oz. | 1.5 | 1.4 | 1.0 |
| Fourth 4 oz. | 1.2 | 1.0 | .3 |
| Fifth | 1. | 1.0 | .05 |

By removing the upper third of milk containing 4% of fat we get approximately a milk containing 10% of fat, and the same percentage of proteid that was in the original milk. This, mixed with two parts of water, will give 3% of fat and 1% of proteid which is a good formula for young babies. These are the two common methods of preparing infants' bottles which I adopt in practice.

The American system of laboratory preparation of milk has not found much favour in this country, and as I have had no experience of it, I need not go into a detailed description .

Holt (42) says: "After over eight years' experience with laboratory feeding I am more than ever convinced of its scientific value, and its practical utility ; and have therefore no hesitation in placing it, when intelligently used, next to maternal nursing." In this method the food is ordered in prescription form, as follows: -

| | | |
|-----|-------------------------|-------------|
| Rx. | Fat | 3% |
| | Sugar | 6% |
| | Proteids | 1% |
| | Alkalinity, Lime water | 5% |
| | Number of feedings | 8. |
| | Amount for each feeding | 4 ounces. |
| | Heat to 155° F. | 30 minutes. |

By using whey a separate modification of the proteids is accomplished, so that within certain limits a larger proportion of lact-albumen can be given. The highest proportion of lact-albumen and the lowest proportion of casein can be given when the total proteids do not exceed 1.15 per cent. Of this 90 per cent may be lact-albumen and .25 per

cent casein. The milk may be delivered raw, or heated to any temperature required. The food for the entire day is delivered each morning in the bottles from which the baby is fed.

The objections to the method are firstly, the expense. In America, Holt calculates that it costs forty to sixty cents a day, (English money, about two shillings) which makes it too expensive for the people who have the greatest trouble in the rearing of infants, namely the working classes. Secondly, in order to carry out the system intelligently, constant medical supervision, and the repeated alteration of prescriptions are necessary. This also adds to the expense; and I think that with the same, or a smaller amount of medical supervision the home modification of milk can be successfully carried on.

In using this method, it may be noted that Holt employs very low percentages of proteid and of fat during the first few months. He recommends for an infant of two weeks old, fat 2 per cent; and proteids .60 per cent. These are much lower percentages than I am in the habit of using. He gradually increases the amount of fat, and more quickly the amount of proteid, till he reaches during the eleventh month of a healthy infant 4 per cent fat, and 2 per cent proteid. I find that the healthy infant in the eleventh month takes ordinary cows' milk perfectly well, without modification.

In feeding infants it is well to begin with a

food containing rather less fat, and less proteid than is found in human milk. A mixture containing about 1 per cent proteid, 2 per cent fat, and 5 per cent sugar, is what I use in the first few weeks of life. If it be well digested, it can be made richer either in proteids or fats by decreasing the water and increasing the milk or the cream.

I do not attach great importance to the exact percentage composition, and for a week old baby I order two teaspoonfuls of milk, one teaspoonful of cream, five teaspoonfuls of water, a teaspoonful of a solution containing half a grain of citrate of soda, and a small teaspoonful of sugar. By adding to this every week a teaspoonful of milk and a teaspoonful of water the amount and strength of each feed is increased. As I make up my own citrate of soda solution, I easily alter it from time to time, so as to give one grain to each ounce of milk. The great value of citrate of soda is found when one sees a child suffering from dyspepsia, who has been fed on a milk and water mixture with lime water or barley water. It is in these cases that one has difficulty in dissuading the mothers from giving the proprietary foods or condensed milk; because they are convinced that their baby cannot digest cows' milk. By putting the child on milk, with two parts or more of water, and soda citrate, the dyspepsia can usually be overcome; and then the amount of milk can be increased, and cream added gradually. Many of these infants digest condensed milk without difficulty, and I used sometimes

to put them on it, but there was great difficulty in getting the parents to change back to cows' milk, with the result that the child suffered from the usual bad effects of a diet deficient in fat and in antiscorbutic properties. I may mention here that I always had difficulty in getting an infant to satisfactorily digest an occasional bottle, to supplement breast-feeding, until I adopted citrate of soda.

The following is an illustrative case. A child, A.Y., a fortnight old, was not gaining weight, crying, and always wanting the breast. The mother had had two children; the last one eight years ago. The breasts were small and apparently did not contain much milk. I gave the child a bottle containing hot water twice daily, without improvement, and then tried a bottle containing three teaspoonfuls milk, five teaspoonfuls water, one teaspoonful lime water, and a teaspoonful of sugar, also twice daily. I had a good nurse and the food was carefully prepared and administered two hours after breast feeding. The result was that the food was vomited. The nurse said "it came up like a spout." The bowels were regular twice daily, and no curd in motion, probably because none of the cows' milk was retained. I substituted for the lime water a solution of citrate of soda, containing half a grain to the teaspoonful, and the child was never once sick; slept peacefully, gained half a pound in the first week, and went on gaining steadily.

Another case showing the advantage of soda ci-

trate over lime water or barley water is the following: - W.I., aged 6 months, was fed on the breast for three months, then the mother's milk became deficient, and he was put on a bottle containing milk and barley water equal parts, with two teaspoonfuls of lime water. He did fairly well for three months on this diet, but usually vomiting slightly after his bottle. He then began to vomit more violently curdled milk immediately after feeding, with much screaming; some diarrhoea, motions very green, watery, and slimy, with undigested curd. He was losing weight. I put him on milk and water equal parts, with one grain of citrate of soda to the ounce of milk, with immediate relief of the discomfort, and gradual improvement in the stools. This treatment was only continued for a week, and then the mother returned to her former method of feeding. The pain returned, not so severely, and the child vomited firmly curdled milk. The bowels became loose, and curd was passed in the stools. The citrate of soda was again prescribed, and the vomiting and diarrhoea ceased. The child was kept on the citrate for three months; the mother trying from time to time to substitute lime water with bad effects,

Dr Poynton (36) summarises the chief facts illustrated in the treatment of fifty cases with citrate of soda, thus: - "All of them were ill when they came here. None of them were healthy babies whom the mother had brought for advice as to how to feed when weaning them because of failure of breast

milk. On the other hand, none of them were urgently ill, though several were almost skeletons. An infant who weighs less than five pounds at four weeks, whether premature or not, is not a very encouraging subject; yet two of them here have done excellently. The arrest of the down-hill course has usually taken about a fortnight, then there is a steady gain of four, five, six, or even seven ounces in a week. I have been cautious in the matter of the dilution of the milk, but now after almost a year's experience, I am more confident; and there are several children of six weeks and two months taking two parts of milk to one of water with comfort. I neglect the excess of proteid when the milk is digested, but must not forget to increase the citrate as the milk is increased. Dr Wright is bold in his advocacy of the non-dilution of milk and gives it undiluted."

I consider that the introduction of this system of feeding is a great advance. In practice the great difficulty in artificial feeding is the digestion of proteids, It is just in these cases that the patent foods and condensed milk are used. If we can provide the mothers with something at once cheap, and efficacious, it is easy to prevail upon them not to use tinned foods. Citrate of soda is very cheap. It costs $2\frac{1}{4}$ a pound, less than twopence an ounce, so that it is easily within the reach of the poorest, It is almost as cheap and as easily used as lime water, which we find in the poorest of houses. The effect upon the infant's condition is

almost instantaneous, and this is a very great advantage, as mothers have very little patience when their child is evidently in pain. No doubt many of the children whom I have successfully fed by this method would have done well on milk, cream and lime water mixtures; but it would have taken time and patience to find out the amount of proteid the child could digest. By the soda citrate method, we can to a certain extent disregard the proteid and secure a sufficient supply of fat. The system is one that can be used in a rough and ready method, the elaborate calculations of the laboratory system of Rotch being unnecessary.

I have only given two illustrative cases, one at the beginning of life, and the other towards the end of bottle feeding; but others could be given much the same in character. I have in some of the poorer and more thriftless cases given no personal supervision; merely directions, prescribed a bottle of citrate of soda; and told the mother that she could have the bottle repeated as often as she liked free of charge, and I have been surprised at the result. They have sent regularly for what they call the "magic" bottle and when I see the children in a few months' time they look every bit as well as breast-fed infants. I may say that in these cases I do not prescribe either cream or top milk, as it would not be given. I recommend two parts milk, one part water, a teaspoonful of sugar, and enough of the citrate solution to give one grain to the ounce of milk, which

I usually make one teaspoonful.

I do not maintain that the use of citrate of soda is the solution of the problem of our excessive infantile mortality, but in my hands it certainly has decreased the number of infants who have been brought up on tinned food, and by so doing has diminished the amount of rickets and scurvy.

In some cases it is found that infants are quite incapable of digesting the casein of cows' milk. This is rare, and is usually temporary. In order to feed the infant during this period either whey, white of egg, or raw meat juice must be used to supply the necessary proteid. I commonly use the two former in epidemic diarrhoea and occasionally have had to use them in ordinary feeding.

Whey contains the sugar and salts of milk, the lact-albumen and some of the fat.

The amount of fat and proteid is small, therefore it is not a means of feeding that can be kept up for long, but by the gradual addition of cream one can restore the deficient ingredients, increasing as quickly as the child can bear it. By the mixture of whey and cream, or top milk; a fluid which is almost identical with human milk can be produced; but the process is one which I find difficulty in getting carried out.

White of egg stirred up in warm water is very useful in diarrhoea. Albumen may also be used in a dried form, as it is found in plasmon, sanatogen,

or somatose. Of course these must not be used for any length of time unless fresh milk is given as well.

Raw meat juice is a useful addition to the diet of weakly children.

I never recommend the use of the proprietary foods. These foods mostly contain starch, all are deficient in fat, and all lack the antiscorbutic property of fresh milk. The starch is in many cases converted into maltose and dextrin, but even in this form it is very questionable whether it is a better carbohydrate food than cane sugar. A food like Mellin's is as good as barley water as a diluent, but has the disadvantage that the mother relies upon it as a food and not as a diluent, and gives too much of it. Allen and Hanbury's No. 1 food does not contain starch and is dried milk with the casein removed and albumen substituted; but it is deficient in fat and is not antiscorbutic. From the number of children brought to me with dyspepsia who have been fed on proprietary foods, I am convinced that they are the cause of a great deal of ill-health.

Condensed milk is another means of feeding which I consider bad. If its price is measured by the amount of fat it contains, then it is more expensive than fresh milk, and contains an excess of sugar. One of the reasons of its popularity is the fact that it is usually given in much greater dilution than fresh milk, and thus the infant does not suffer from proteid dyspepsia, also the curd of condensed

milk is finer than that of fresh.

A very important factor in the successful feeding of infants is regularity of meals and the giving of a suitable quantity at each feed. The new-born child ought to be fed every two hours. This I always try to carry out very strictly, as mothers are unwilling to waken the child in order to feed it. After the first ten days it is usually found that the child wakens punctually. During the night, that is from 10 p.m. to 7 a.m. I recommend that the child should be allowed to sleep as long as it can; but that during the first month two feeds are to be given nightly. From the second to the ninth month one feed during the night ought to be sufficient, and after that night feeding ought if possible to be stopped.

It is impossible to lay down hard and fast rules as to the amount to be given in each feed. The appetite and size of stomach appear to vary a good deal. Holt (43) estimates that a breast-fed child sucks during the first week from $\frac{5}{8}$ to $1\frac{1}{2}$ ounces each time; during the second week one to three ounces; during the third week one and a half to four ounces; and goes on increasing till during the sixth month four to seven ounces are being sucked. These figures may be taken as a guide, and I usually begin with an ounce and a half and increase gradually, depending rather, upon whether the child appears to be satisfied, than upon a table of quantities suitable for the several months.

I have shown that the infantile death rate in this country is excessive and that the most important cause of this loss of life is improper artificial feeding. I have described the general principles on which artificial feeding ought to be carried out which I here recapitulate.

1. That cows' milk must be the basis of the food.

2. That this milk should be as fresh and as clean as possible.

3. That it is necessary to boil the milk during the months of July, August and September, owing to the prevalence of diarrhoea, but that as a rule it ought to be given raw.

4. That in order to render the milk digestible it must be diluted and that if this is not sufficient, the easiest and best method of making the casein of cows' milk easy of digestion is by the addition of citrate of soda.

5. That to bring the fat of the food up to the standard of human milk, it is necessary either to add cream or to use "top milk."

6. That the "laboratory" feeding of infants is not practicable among the poor, and therefore does not touch the question of the excessive infantile mortality.

7. That condensed milk and the proprietary foods are to be avoided.

The methods of feeding which I have described contain nothing novel, but I find that medical men in this district are not in agreement with me, especially in the matter of the proprietary foods. They are largely prescribed, and I think with injury to the infant.

The use of citrate of soda is not so widely known as it deserves to be. If it be once tried I am sure it will not be given up, at least, until something better is devised.

Last year's returns of the Registrar-General are hopeful, and I trust that they show that infant feeding is being more carefully carried out; but one year's returns are not of very great value. However, I view with hope the prospects of infant life in this country. Families are becoming smaller, so the mother has more time to devote to her children. The Society for the Prevention of Cruelty to Children is doing good, by setting up a standard of cleanliness. The sanitary authorities are paying more attention to the sanitation of dairy farms, and the control of the milk supply; and the State is beginning to realise that the health of our children is a valuable national asset.

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